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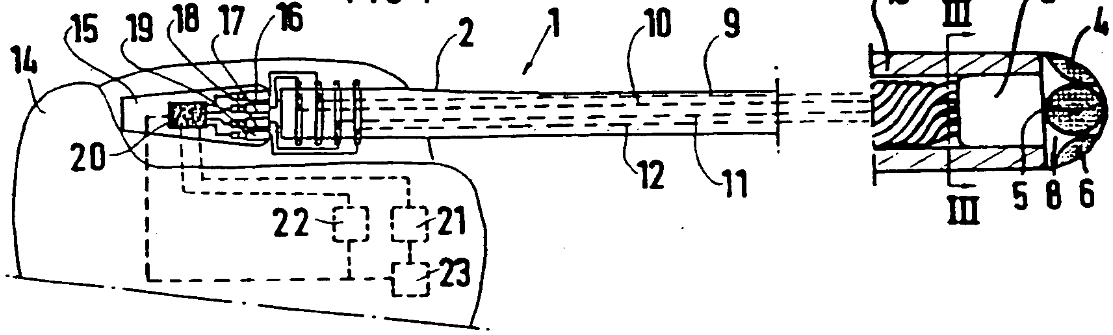
(54) Heart stimulation apparatus.

(57) The invention relates to a heart stimulation apparatus (14) for intracardial stimulation of heart tissue comprising an electrode device (1) with an electrode head (3) provided on the distal end thereof, having at least a first conductive surface (4 - 7) and a second conductive surface (4 - 7), a stimulation pulse generator (21) and a switch (15) for selectively connecting the conductive surface(s) (4 - 7) to the stimulation pulse generator (21) in any possible combination. In order to reduce the energy consumption, an autocapture means (23) is provided which automatically test a number of possible combinations of conductive surfaces (4 - 7) for stimulation and selects the combination providing the lowest stimulation threshold.

FIG 1



EP 0 571 797 A1

This invention relates to a heart stimulation apparatus for intracardial stimulation of heart tissue and/or sensing heart signals comprising an electrode device with an electrode head installed on the distal end thereof, whereby the electrode head is equipped with at least a first conductive surface for stimulating heart tissue and/or sensing heart signals connected to a first conductor and a second conductive surface for stimulating heart tissue and/or sensing heart signals, said second conductive surface is insulated from the first conductive surface and connected to a second conductor, insulated from the first conductor, a stimulation pulse generator and/or a detector and a switch for connecting one conductive surface, or a plurality of conductive surfaces, to the stimulation pulse generator and/or the detector in any desired manner.

U.S. patent 4,628,934 describes a heart stimulation apparatus in which an electrode device's distal end can be provided with a plurality of independently connectable electrodes. The ring electrodes described in the patent are installed relatively far apart, and a conductive electrode tip does not solve the problems the present application addresses.

An electrode device is prior art through U S patent 3,911,928. A plurality of relatively small conductive surfaces are arrayed on the head of the electrode device in order to reduce the threshold value and, thus, energy consumption. All the conductive surfaces on the head of this electrode device are connected to the same conductor. This can result in needlessly heavy energy consumption, since some of the conductive surfaces are not in contact with heart tissue for stimulation.

U.S. patent 4,760,852 describes a pacemaker electrode whose distal end has a plurality of relatively large conductive surfaces connected to the same conductor.

The object of the invention is to achieve a heart stimulation apparatus of the above-described type with which an optimal threshold value for each patient and therefore the lowest energy consumption is always attained. Another objective is to achieve optimal sensing of heart signals.

This problem is solved with a heart stimulation apparatus in which the switch is controlled with the aid of an autocapture means in such a way that the conductive surfaces are automatically connected in different combinations, via the conductors, to the stimulation pulse generator in order to achieve optimal stimulation with minimized energy consumption.

As a result of this design for the heart stimulation apparatus, the stimulation surface(s) which provide(s) the lowest stimulation threshold is automatically selected.

It is in this connection an advantage if one conductive surface serves as the stimulation electrode, and the other conductive surface(s) serves as indifferent electrode.

With, for instance, three conductive surfaces, a stimulation pulse may be delivered unipolarly via one of the surfaces, a combination of two surfaces or three surfaces, or bipolary between two single surfaces or between a single surface and a double surface. The autocapture means may test all possible combinations or a selected number of combinations programmed by a physician.

Further, the stimulation pulses could also be displaced in time and amplitude at the different surfaces. This means that the duration of pulses could vary, but it also means that a second pulse could arrive before a preceding pulse emitted. In this manner, a pulse can be given the exact morphology desired. Analogously, the sensing of heart signals can be made from the surface(s) providing the lowest sensing threshold.

When stimulating bipolarly, it is an advantage if the conductive surface providing the lowest stimulation threshold is connected to a negative output of the stimulation pulse generator.

Another advantageous version of the heart stimulation apparatus is achieved when the number and choice of conductive surfaces, connected via the conductor(s) to the detector for sensing, are selected independently of the conductive surface(s) employed for stimulation. This results in a large selection of sensing surfaces on the electrode head. The sensing surface may be selectable in such a way that it is not the same surface used for stimulation. This would be an advantage in sensing immediately after a stimulation, since the stimulating surface is then polarized, and any sensing could "drown" in the stimulation surface's polarization voltage. According to the invention, it is proposed that all the conductive surfaces even be connected to the detector for sensing.

According to another embodiment of the invention, it is proposed that the conductive surfaces be evenly distributed over the electrode head. In this way, one or more electrode surface(s) would always be optimally placed against heart tissue.

According to an additional embodiment of the invention, it is proposed that the electrode head be hemispherical and that the conductive surfaces be arrayed close to one another. In this manner, a relatively large number of conductive surfaces can be installed on a very small electrode head. The shape of the electrode head ensures that heart tissue is not damaged.

According to one preferred embodiment of the invention, the center of the electrode head has a projecting part with a conductive surface. Since the projecting part is extremely small, this part has at least a chance of retaining contact with heart tissue if the electrode head becomes dislocated.

One version of the invention, simple in design respects, proposes that the electrode head consist of at least two conductive bodies which are insulated from one another. With such an embodiment design, the electrode head can have a configuration in which one of the conductive bodies is displaced in relation to the other. The free end of the projecting body, in addition to the sides of the free end, can be insulated to prevent any conduction between the conductive surfaces of the bodies. As a result of the structure of the electrode head, the conductive surfaces of one body or another, or of both bodies, can be used for simultaneous stimulation of heart tissue and/or sensing of heart signals.

Another embodiment of the invention proposes that the electrode head be equipped with a traumatic fixation component on which at least one conductive surface is provided. This achieves both fixation of the electrode head to the heart wall and ensures that at least two conductive surfaces are in contact with heart tissue.

In one constructively simple embodiment of the invention, it is proposed that the fixation component be helical. In this way, the electrode head can be partially screwed into heart tissue.

According to one preferred embodiment of the invention, at least one of the conductive surfaces is made of a microporous material. As a result of the microporous material, the stimulation electrode and the indifferent electrode can be made very small while the conductive surfaces are relatively large at the same time.

According to the invention, at least one of the conductive surfaces can also be coated with a layer of ion exchange material. The ion exchange material serves e.g. as protection against soiling particles. The conductive surfaces are highly sensitive to such particles, particularly when the surfaces are made from a microporous material.

The invention can suitably be refined by having a coating of medication on at least one of the conductive surfaces. This coating has an antiinflammatory effect when the electrode head presses against or is screwed into the heart wall. In this manner formation of fibrous tissue around the electrode head, something which otherwise could occur is avoided or reduced.

The invention will be described in greater detail in conjunction with the accompanying drawings, in which

FIG. 1 is a side view of a heart stimulation apparatus to which an electrode device according to the invention is connected and shown with an enlarged electrode head, partly in cross-section;

FIG. 2 shows a block diagram illustrating the autocapture arrangement in more detail;

FIG. 3 illustrates in a flow chart one possible autocapture routine which the heart stimulation apparatus may perform;

FIG. 4 illustrates in a flow chart another possible autocapture routine which the heart stimulation apparatus may perform;

FIG. 5 is frontal view of an electrode head according to FIG. 1;

FIG. 6 is a cross-section of the electrode device through the section line III-III in FIG. 1;

FIG. 7 is a side view of a heart stimulation apparatus, to which an electrode device according to the invention is attached, with an enlarged electrode head shown in cross-section and with another embodiment of the electrode head than the one shown in FIG. 1;

FIG. 8 is a side view of the distal end of the electrode device, shown in cross-section, according to the invention; and

FIG. 9 is another embodiment of the distal end than the one shown in FIG. 8.

FIG. 1 depicts a heart stimulation apparatus 14 for intracardial stimulation of the heart tissue of a patient and/or sensing heart signals. The apparatus 14 comprises an electrode device 1 containing an electrode cable 2 equipped with a hemispherical electrode head 3 at its distal end. The electrode head 3 is fitted with four round, closely spaced conductive surfaces 4, 5, 6, 7 which are evenly distributed on the electrode head 3 and which are electrically separated by insulating material 8. The conductive surface 7 is hidden in this Figure 1. Each conductive surface 4, 5, 6, 7 is connected to its own elongate, flexible conductor 9, 10, 11, 12 extending to the proximal end of the electrode cable, the conductors 9, 10, 11, 12 insulated from one another. The electrode cable 2 is also provided with an external layer of insulation 13. The heart stimulation apparatus 14 is connected to the proximal end of the electrode cable 2. The heart stimulation apparatus 14 further comprises a switch 15 with four output terminals 16, 17, 18, 19, each connected to its own conductor 9, 10, 11, 12 for the conductive surfaces 4, 5, 6, 7 on the electrode head 3. The switch 15 also has an electronics unit 20 connected to the output terminals 16, 17, 18, 19. The heart stimulation apparatus 14 additionally contains a stimulation pulse generator 21 and a detector 22 for sensing, each of which

individually connected to the electronics unit 20, and an autocapture function unit 23 which is connected to the stimulation pulse generator 21, to the detector 22 and to the electronics unit 20.

FIG. 2 shows that the conductive surfaces 4, 5, 6, 7 are evenly arrayed on the electrode head 3. The conductive surfaces 4, 5, 6, 7 are the ends of wires made from a conductive material whose other ends are connected to one of the conductors 9, 10, 11, 12, insulated from one another, as shown in cross-section through the electrode device in FIG. 3.

After the electrode cable 2 has been introduced into the patient's heart in the known manner and the electrode head is applied to heart tissue, the stimulation generator 21 is switched via the electronics unit 20 , e.g. via output terminal 18 and conductor 11, to the conductive surface 6, a voltage for stimulating the heart tissue then being applied to said surface 6. The detector 22 is then switched in the same way, via the electronics unit 20, via one or more of the output terminals 16, 17, 18, 19 and via the corresponding conductor 9, 10, 11, 12, to one or more conductive surfaces 4, 5, 6, 7 for sensing heart signals. The number and selection of conductive surfaces 4, 5, 6, 7 connected to the detector 22, via one or more of the conductors 9, 10, 11, 12, can be selected independently of the conductive surface(s) 4, 5, 6, 7 employed for sensing. All conductive surfaces 4, 5, 6, 7 can be switched with advantage to the detector 22.

In FIG. 4 the structure in the heart stimulation apparatus 14 which executes the autocapture function and selection of electrode surface configuration is shown in a block diagram. The stimulation pulse generator 21, detector 22 and autocapture funciton unit 23 are, as also shown in FIG. 1, connected to the electronics unit 20. In the electronics unit 20 a first switch 121 is connected between output terminal 16 and stimulation pulse generator 21, a second switch 122 is connected between the output terminal 17 and the stimulation pulse generator 21, a third switch 123 is connected between output terminal 18 and the stimulation pulse generator 21, a fourth switch 124 is connected between output terminal 19 and the stimulation pulse generator 21, a fifth switch 125 is connected between output terminal 16 and the detector 22, a sixth switch 126 is connected between output terminal 17 and the detector 22, a seventh switch 127 is connected between output terminal 18 and the detector 22 and an eighth switch 128 is connected between output terminal 19 and the detector 22. The switches 121 - 128 can, when activated by the autocapture function unit 23, selectively connect any output terminal 16, 17, 18, 19 or combination of output terminals 16, 17, 18, 19 to the pulse generator 21 and/or detector 22 respectively. Further, a ninth switch 129 can connect neither, either or both of the stimulation pulse generator 21 and detector 22 to the heart stimulation apparatus's 14 case for unipolar stimulation and sensing. The autocapture function unit 23 is programmed to automatically search for the conductive surface combination which results in the lowest stimulation threshold. This means that the autocapture function unit 23 will selectively, through the switches 121 to 129 test a sequence of different stimulation arrangements and select the most efficient one.

The autocapture function in itself is known. Basically, it is performed by reducing the stimulation energy until there is no reaction from the heart, i.e. no capture, whereafter the stimulation energy is increased until a capture is detected by the detector 22 and the threshold is determined.

FIG. 5 illustrates one possible flow chart for performing a selection of the ten lowest thresholds of all programmed combinations. The number of possible combinations could be larger than the number of programmed combinations. This because it may, for instance, not be suitable to stimulate bipolarly between two conductive surfaces which are located too closely to each other.

The flow chart commences with the first block by starting TEST A and assign the first combination (n: = 1). The function will then proceed with the selection and connection of the first electrode combination, i.e. first combination of conductive surfaces 4, 5, 6, 7, and the threshold is determined for the first combination in a known manner. As this TEST A shall select the ten combinations having the lowest threshold a question block inquires whether the number n has exceeded ten selections. If not, the actual combination and threshold determined will be immediately stored and the number for the actual combination will be incremented by one (n: = n + 1). In the next question block it is determined whether all possible combinations N has been tested yet. If so, the test is ended and the ten combinations showing the lowest stimulation threshold will be stored in a memory. If TEST A has not run through all combinations, the next is selected and its threshold determined.

When the number of tested combinations exceeds ten (YES in block n>10?), the determined threshold for the actual combination will be compared with the stored thresholds and if any stored threshold is higher than the presently determined threshold (YES in block IS STORED THRESHOLD HIGHER?) the stored combination will be replaced with the present combination and threshold. The number of tested combinations is now incremented and the function proceeds as described above.

It should be noted that this flow chart only indicates the carrying out of the autocapture function. If the number of possible combinations is large, it could be very inconvenient for a patient if the heart stimulation apparatus was to run through all combinations in uninterrupted sequence. In particular the block DETER-

MINE THRESHOLD could therefore include timing functions reducing the number of tests per hour or the like. When no specific combination has been selected automatically the heart will be stimulated using either a combination and stimulation energy selected by a physician or a combination and stimulation energy previously chosen by the autocapture function.

FIG. 6 illustrates a flow chart for a TEST B. TEST B is a continuation of TEST A and in TEST B the stored ten combinations are tested to determine which of the ten that has the lowest threshold. TEST B could be routinely performed by the heart stimulation apparatus 14 to ensure that it is the combination having the lowest threshold that is permanently activated.

The flow chart begins with a START TEST B block, which could be initiated automatically at selected time intervals by the autocapture function unit 23. The first combination is then addressed (m: = 1) and selected in the next block. As in TEST A the threshold is determined. In TEST B it is only relevant to find the combination having the lowest threshold and the first threshold will therefore be stored to be compared with other combinations. In the next block the number for the combination is incremented and the function controls if all combinations have been checked yet in which case TEST B is ended. Otherwise the next combination is selected and its threshold determined. The present combination and its threshold is now compared with the stored combination and threshold and if the stored threshold is higher, the present combination and threshold will replace the previously stored combination and threshold and the function proceeds by incrementing the number of combinations. If the stored threshold is lower than the actual threshold the function will only proceed to check out the next combination. When TEST B is ended the autocapture function unit will use the selected combination until a new test may indicate that another number of combination is preferable, or when a physician by telemetry by means of an external programming unit selects a different combination for stimulation.

Analogously the autocapture function unit may select a combination of conductive surfaces 4, 5, 6, 7 which provides the best sensing level for the detector 22.

It may be convenient if the block DETERMINE THRESHOLD in TEST B, as in TEST A, is provided with means for prolonging the entire test so that the patient will be as unaffected by the TEST as possible.

There are other possible test routines which the autocapture function unit 23 may execute. For example, it may test all possible unipolar stimulation combinations and permanently select the conductive surface(s) providing the lowest threshold as stimulation electrode in a bipolar combination. The conductive surface(s) serving as stimulation electrode should in this connection be connected to a negative output of the stimulation pulse generator 21 as this will provide a lower threshold then if the stimulation electrode were to be connected to a positive output. Further, when connected bipolarly the autocapture function unit 23 may switch the connection so that the negative conductive surface(s) becomes positive and vice versa. The pole change may be executed automatically if an increase in the threshold is detected by the autocapture function unit 23, thereby testing which of the two combinations provides the lowest threshold.

FIG. 7 shows a heart stimulation apparatus 224 with a function corresponding to the function shown and described in FIG. 1. An electrode device 225, whose design only differs from the previously illustrated and described electrode device 1 by having a different configuration for the electrode head, is connected to this heart stimulation apparatus 224. Thus, the electrode device 225 contains a cable 226 on whose distal end an electrode head 227 is provided. The electrode head 227 consists of two conductive bodies, 228, 229 which are electrically insulated from one another by a layer of insulation 230. The center of the body 228 is equipped with a through opening in which the body 229 is inserted. The bodies 228, 229 are also displaced in relation to one another so the electrode head's 227 center, as seen from the side, has a projecting part formed by the body 229, the side of the partially free end of this body having a conductive surface 231. The free surface of the body 228 forms a second conductive surface 232. Since the insulation 230 covers the body 229, in addition to the end side, no electrical conduction can occur between the conductive surfaces 231, 232. These conductive surfaces 231, 232 are connected to a respective elongate, flexible, insulated conductor 233, 234 extending to the electrode cable's 226 proximal end and connected to their respective output terminal 235, 236 on a switch 237 which also contains an electronics unit 220 which functions analogously with the previously described electronics unit 20. The electronics unit 220 is, in turn, connected to a stimulation pulse generator 221, a detector 222 and a function unit 223 for autocapture. The electrode cable 226 is also provided with an external layer of insulation 238. As a result of the described electrode device with its electrode head 227, either the conductive surface 231 or the conductive surface 232, or both surfaces 231, 232 in combination, can be used for stimulating a patient's heart tissue and/or sensing heart signals.

FIG. 8 shows the distal end of a bipolar electrode device for intracardial stimulation of heart tissue in a patient. The electrode device contains an electrode cable 301 on whose distal end an electrode head 302 with a helical fixation device 303 is installed. The electrode head 302 is provided with two conductive

surfaces 304,305, each connected to its own elongate conductor 306, 307 which runs inside the electrode cable 301 and extends to the proximal end of the electrode cable, said conductors 306, 307 insulated from one another by a layer of insulation 308. The electrode cable 301 is also provided with an external layer of insulation 309. This FIG. shows that one of the conductive surfaces 305 can be provided on the anterior end of the fixation device 303, and the rest of the fixation device is provided with an insulating surface coating 310, the conductive surface 304 forming a ring around the seat of the fixation device 303. The conductive surfaces 304, 305 are made of a microporous material, such as titanium nitride. To protect these surfaces 304, 305 from soiling particles, the surfaces are coated with a layer of ion exchange material 311 which, in this embodiment, is in turn coated with a layer of medication 312 which is to exert e.g. an antiinflammatory effect when the electrode is applied. The conductors 306, 307 for the conductive surfaces 304, 305 can be connected in an optional manner to different poles in a pacemaker (not shown) in such a way that conductive surface 304, for example, serves as an indifferent electrode and conductive surface 305 serves as a stimulation electrode. When necessary, the conductive surface 305 can consequently serve as the indifferent electrode and the conductive surface 304 be used as the stimulation electrode.

FIG. 9 shows a non-traumatic electrode device containing an electrode cable 313 on whose distal end an electrode head 314 is installed. The electrode head 314 is made up of two conductive bodies 315, 316 which are electrically insulated from one another by a layer of insulation 317. The center of the body 315 is provided with a through opening in which the body 316 is installed. The bodies 315, 316 are even displaced in relation to one another so the center of the electrode head 314, seen in profile, has a protruding part formed by the body 316, the partially free end side of this body consisting of a conductive surface 318. The free surface of the body 315 forms a second conductive surface 319. Each of the conductive surfaces 318, 319 is connected to an elongate flexible individually insulated conductor 320, 321 which runs to the proximal end of the electrode cable 313. The electrode cable 313 is also provided with an external layer of insulation 322. With the electrode device and its electrode head 14, as described in this FIG., either the conductive surface 318 or the conductive surface 319 can be connected to a pacemaker in such a way that either, as described referring to FIG. 8, can serve as an indifferent electrode or as a stimulation electrode. Conductive surfaces 318, 319, which are made of a microporous material, can, like conductive surfaces 304, 305 in FIG. 8, be coated with an ion exchange material and with a layer of medication, even if this is not shown in this Figure 9.

The electrode device's electrode head according to the invention is not limited to the described embodiments. The essential thing is that the conductive surfaces on the electrode head are electrically insulated from one another so the operator has an opportunity to use one or a desired combination of several conductive surfaces for attaining optimal stimulation with minimal energy consumption. The number of conductive surfaces is not limited. In addition, the size and shape of all or some of the surfaces can vary.

REFERENCE LIST	
1, 225	Electrode device
2, 226, 301, 313	Electrode cable
3, 227, 302, 314	Electrode head
4, 5, 6, 7, 231, 232, 304, 305, 318, 319	Conductive surface
8	Insulation material
9, 10, 11, 12, 233, 234, 306, 307, 320, 321	Conductor
13, 230, 238, 308, 309, 317	Layer of insulation
14, 224	Heart stimulation apparatus
15, 237, 121 - 129	Switch
16, 17, 18, 19, 235, 236	Output terminal
20, 220	Electronics unit
21, 221	Stimulation pulse generator
22, 222	Detector
23, 223	Function unit for autocapture
228, 229, 315, 316	Conductive body
303	Fixation device
310	Insulating surface coating
311	Layer of ion exchange material
312	Layer of medication
315, 316	Conductive body

Claims

1. A heart stimulating apparatus for intracardial stimulation of heart tissue and/or sensing heart signals comprising an electrode device with an electrode head installed on the distal end thereof, whereby the electrode head is equipped with at least a first conductive surface for stimulating heart tissue and/or sensing heart signals connected to a first conductor and a second conductive surface (4 - 7; 231, 232; 304, 305; 318, 319) for stimulating heart tissue and/or sensing heart signals, said second conductive surface (4 - 7; 231, 232; 304, 305; 318, 319) is insulated from the first conductive surface (4 - 7; 231, 232; 304, 305; 318, 319) and connected to a second conductor (9 - 12; 233, 234; 306, 307; 320, 321), insulated from the first conductor (9 - 12; 233, 234; 306, 307; 320, 321), a stimulation pulse generator (21; 221) and/or a detector (22; 222) and a switch (15; 237) for connecting one conductive surface (4 - 7; 231, 232), or a plurality of conductive surfaces (4 - 7; 231, 232), to the stimulation pulse generator (21; 221) and/or the detector (22; 222) in any desired manner, **characterized in** that the switch (15; 237) is controlled with the aid of an autocapture means in such a way that the conductive surfaces (4 - 7; 231, 232) are automatically connected in different combinations, via the conductors (9 - 12; 233, 234), to the stimulation pulse generator (21; 221) in order to achieve optimal stimulation with minimized energy consumption.

2. A heart stimulation apparatus as claimed in claim 1, wherein one conductive surface (4 - 7; 231, 232; 304, 305; 318, 319) serves as the stimulation electrode, and the other conductive surface(s) (4 - 7; 231, 232; 304, 305; 318, 319) serves as the indifferent electrode.

3. A heart stimulation apparatus as claimed in claim 1 or 2, wherein the conductive surface(s) (4 - 7; 231, 232; 304, 305; 318, 319) that provides the lowest stimulation threshold is connected to a negative output of the stimulation pulse generator (21; 221).

4. A heart stimulation apparatus as claimed in claim 1 - 3, wherein thet number and choice of conductive surfaces (4 - 7; 231, 232), connected via the conductor(s) (9 - 12; 233, 234) to the detector (22; 222) for sensing, are selected independently of the conductive surface(s) (4 - 7; 231, 232) employed for stimulation.

5. A heart stimulation apparatus as claimed in any of claims 1 - 4, wherein all the conductive surfaces (4 - 7; 331, 332) are connected to the detector (22; 222) for sensing.

6. A heart stimulation apparatus as claimed in any of claims 1 - 5, wherein the electrode head (227) consists of at least two conductive bodies (228, 229) which are insulated from one another.

7. A heart stimulation apparatus as claimed in claim 6, wherein the center of the electrode head (227) has a projecting part (229) with a conductive surface (231).

8. A heart stimulation apparatus as claimed in any of claims 1 - 6, wherein the electrode head (302) is equipped with a traumatic fixation component (303) on which at least one conductive surface (305) is provided.

9. A heart stimulation apparatus as claimed in claim 8, wherein the fixation component (303) is helical.

10. A heart stimulation apparatus as claimed in any of claims 1 - 5, wherein the conductive surfaces (4 - 7; 231, 232) are evenly arrayed on the electrode head (3; 237).

11. A heart stimulation apparatus as claimed in any of claims 1 - 5, wherein the electrode head (3) is hemispherical and the conductive surfaces (4 - 7) are arrayed close to one another.

12. A heart stimulation apparatus as claimed in any of claims 1 - 11, wherein at least one of the conductive surfaces (304, 305; 318, 319) is made of a microporous material.

13. A heart stimulation apparatus as claimed in claim 12, wherein at least one of the conductive surfaces (304, 305,; 318, 319) is coated with a layer of an ion exchange material (311).

14. A heart stimulation apparatus as claimed in claim 13, wherein at least one of the conductive surfaces (304, 305; 318, 319) is coated with a layer of medication (312).

FIG 1

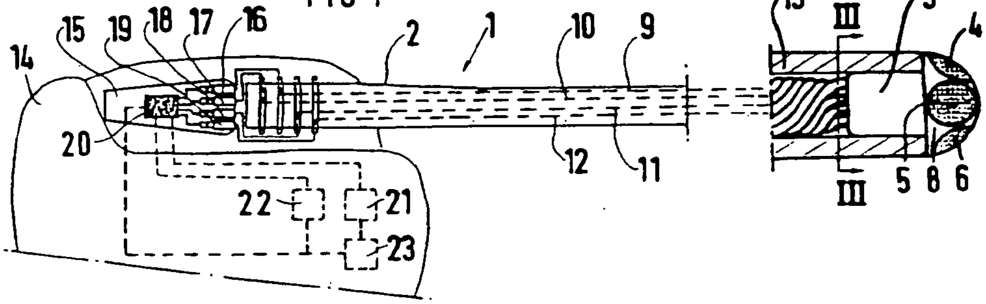


FIG 3

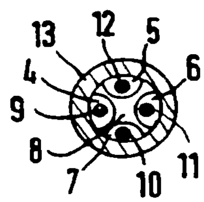


FIG 2

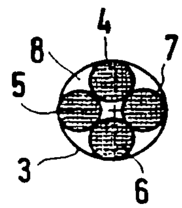


FIG 7

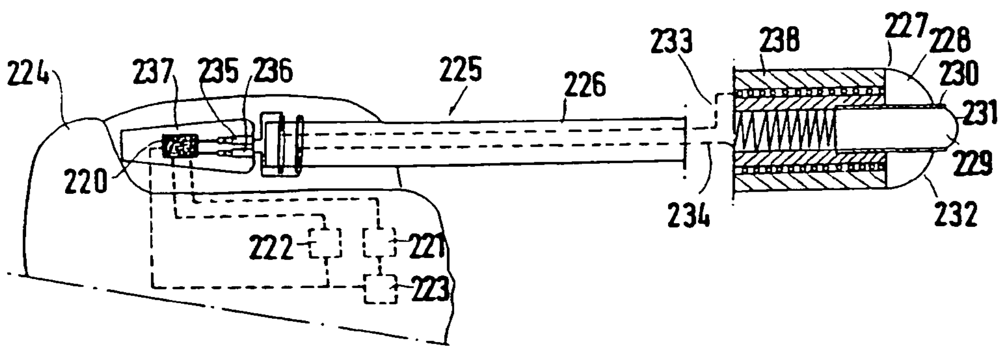


FIG 4

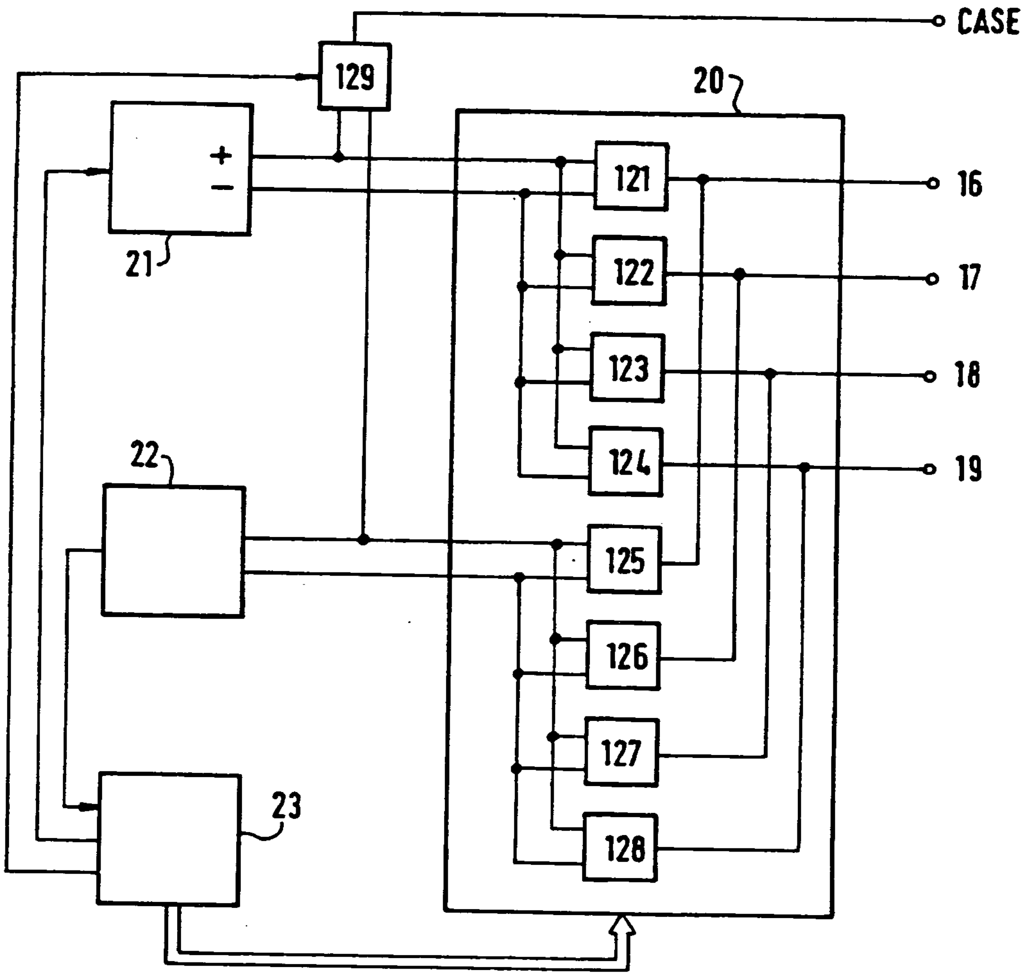


FIG 5

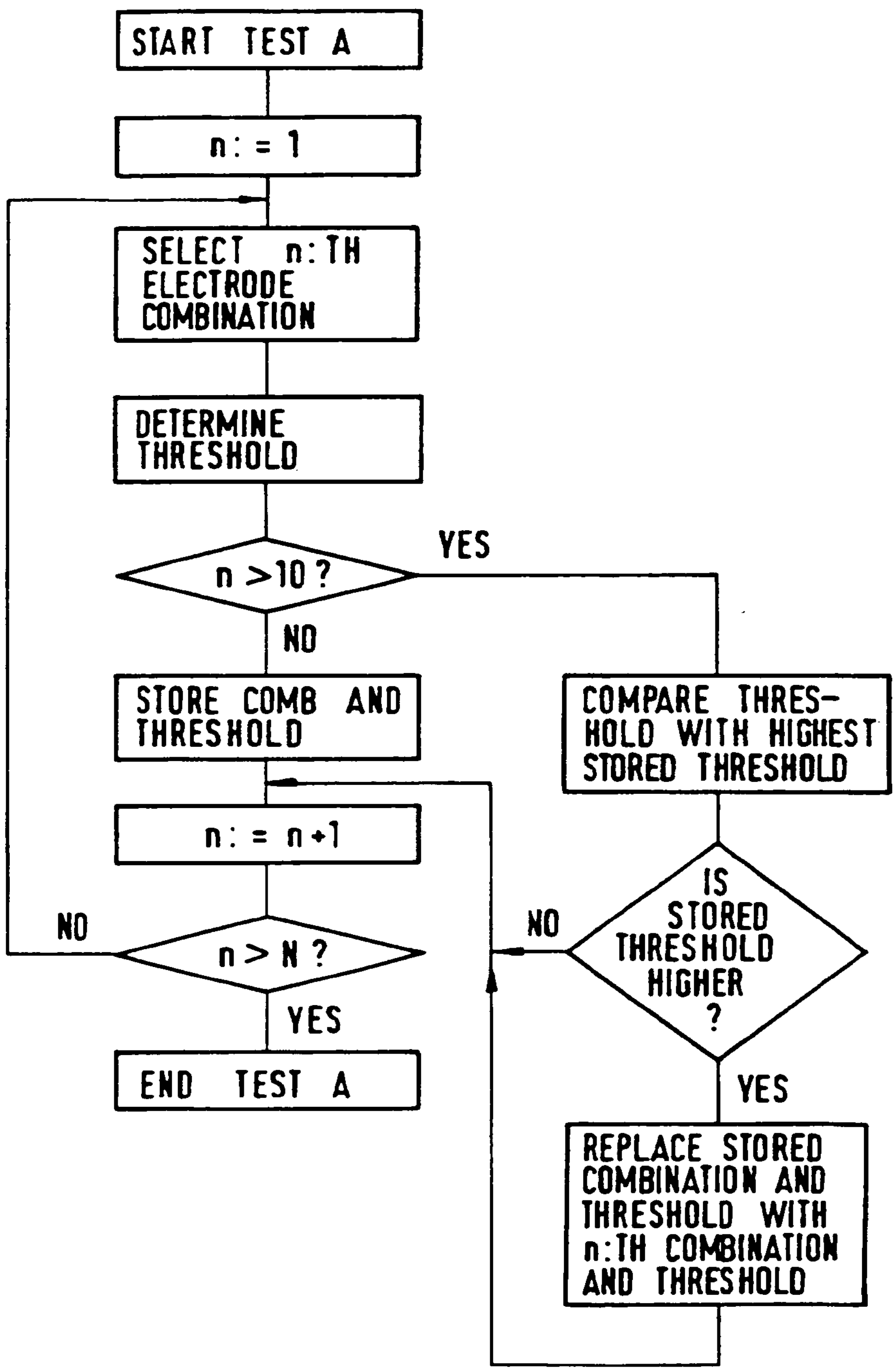

START TEST A
n: = 1
SELECT n:TH ELECTRODE COMBINATION
DETERMINE THRESHOLD
n >10 ?
YES
NO
STORE COMB AND THRESHOLD
COMPARE THRESHOLD WITH HIGHEST STORED THRESHOLD
n: = n+1
NO
n > N ?
YES
END TEST A
NO
IS STORED THRESHOLD HIGHER ?
YES
REPLACE STORED COMBINATION AND THRESHOLD WITH n:TH COMBINATION AND THRESHOLD

FIG 6

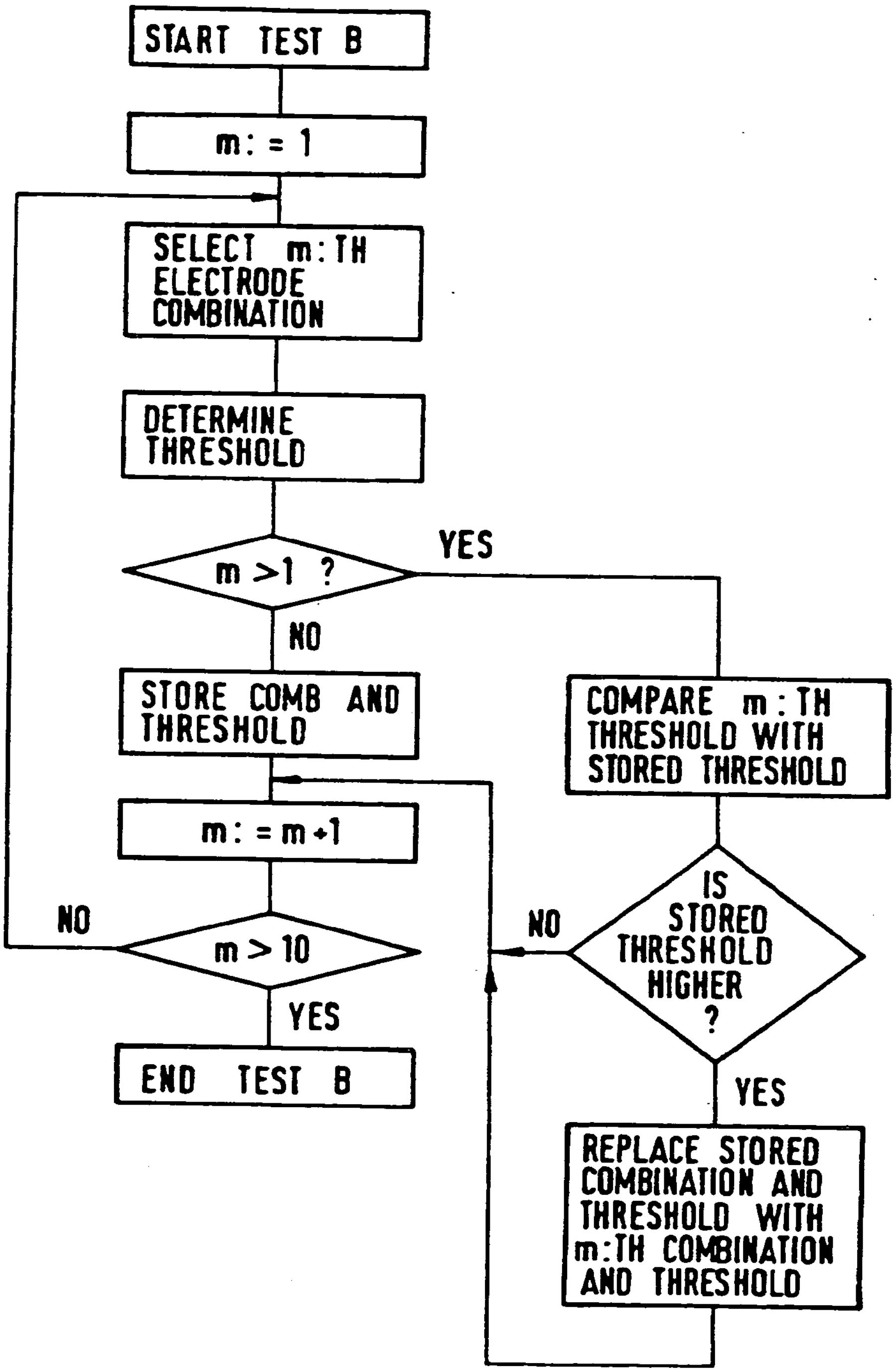
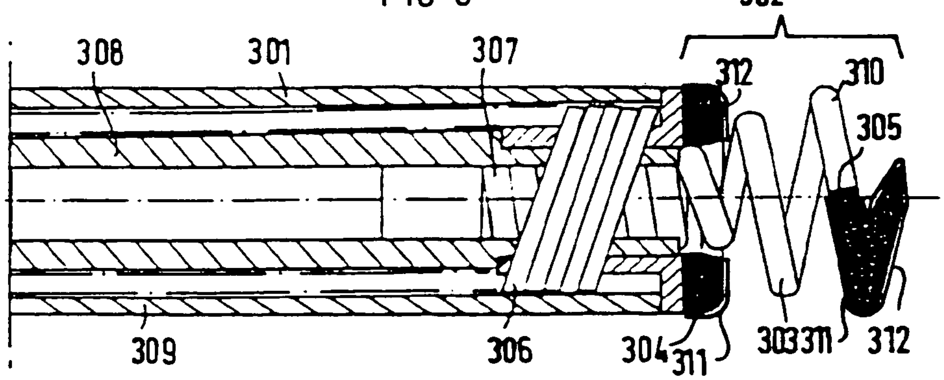

START TEST B
m: = 1
SELECT m:TH ELECTRODE COMBINATION
DETERMINE THRESHOLD
m >1 ?
YES
NO
STORE COMB AND THRESHOLD
COMPARE m:TH THRESHOLD WITH STORED THRESHOLD
m: = m+1
NO
m > 10
YES
END TEST B
NO
IS STORED THRESHOLD HIGHER ?
YES
REPLACE STORED COMBINATION AND THRESHOLD WITH m:TH COMBINATION AND THRESHOLD

FIG 8


302
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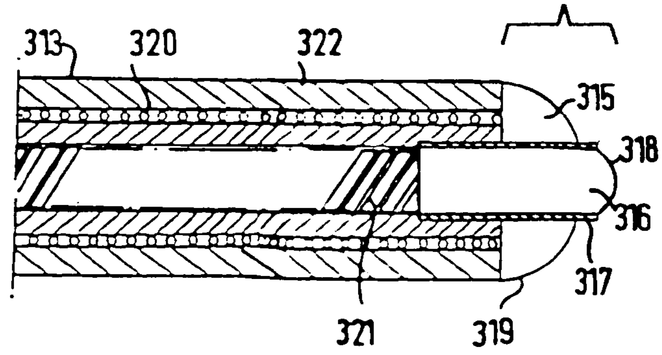
312

FIG 9


314
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319

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP93107473.6

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	US-A-4 848 352 (PETER J. POHNDORF ET AL) *figures 4, 8; claim 1*	1,4-7 10-11	A 61 N 1/05 A 61 B 5/042
A		2-3,8-9,12-14	
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Y	US-A-4 628 934 (PETER J. POHNDORF ET AL) *figure 1; claim 1*	1,4-7, 10-11	
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A	US-A-4 955 382 (MITCHEL FRANZ ET AL) *column 18, line 26-line 38; figure 17*	1-14	
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A	US-A-3 911 928 (HANS LAGERGREN) *whole document*	1-14	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
STOCKHOLM	17.08.1993	BENGTSSON. R.

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